WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Predicting Long-term Wetland Hydrology Using Hydric Soil Field Indicators

Focus Categories: WL, GW, NU

Keywords: Wetlands, Soil-water relationships, Groundwater modeling, Hydric soils

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Statement of Critical Regional and State Water Problems

Current regulations governing wetland identification make it virtually impossible to identify freshwater wetlands routinely using current technology. Jurisdictional wetlands include areas that are saturated within 30 cm of the surface for 5% of the growing season in 5 or more years out of 10. Such information on wetland hydrology can be obtained by long-term monitoring studies that span both wet and dry years. These require long periods of time (5 to 10 years) to complete, and are too expensive to do at most sites where the information is needed. An alternative approach is to use hydrologic models to estimate water table data over long periods at a few benchmark sites. These data can be obtained quickly (in less than 6 months). The hydrologic information can be extrapolated to other soils by calibrating soil indicators of saturation for the specific frequencies and durations of saturation estimated by the model. These indicators (termed hydric soil field indicators) occur in most wet soils that are chemically reduced and can be easily identified during on-site inspections. By using hydrologic models in combination with hydric soil field indicators, we should be able to estimate quickly and economically how long the major soils are saturated in the Coastal Plain region of North Carolina. This information should be of great value to those charged with determining wetland boundaries.

Results and Benefits Expected

A. Procedures to Identify Wetland Hydrology On-Site:

The depths over which water table levels fluctuate in soils are normally estimated from the soils' color patterns (hydric soil indicators). No data on frequency or duration of saturation can be gleaned from the color patterns themselves. Interpretations of these indicators are simply guesses that are not checked against long-term water table data because such data are difficult to acquire. This study will apply an innovative approach to calibrate soil color patterns to long-term saturation frequency and duration at benchmark soils in the Coastal Plain. We will also calibrate the colors to hydrology in areas that have been ditched as well as areas where the hydrology has not been altered. This information will have immediate impact on wetland identification by providing tools that can be applied on-site in a single day to evaluate wetland hydrology.

B. Nutrient Loads in Groundwater, and Nutrient Cycling

Groundwater will be monitored for concentrations of N, P, S, and Fe as well as other chemical constituents. These measurements will be used along with redox potential measurements to determine whether the hydric soil indicators are currently forming, and also to assess which nutrient cycling processes (e.g. denitrification, sulfate reduction) are occurring. Results from this study will also determine whether hydric soil indicators can be used to estimate the degree that these wetland functions are occurring.

C. Use of Landscape Features to Predict Buffer Strip Effectiveness

Hydric soils can be used for buffer strips. This study will evaluate how soil color can be used to estimate depths to where denitrification and sulfate reduction will occur. These results could help establish the edge of where buffer strips will be most effective for water quality enhancement. The modeling work will also determine groundwater pathways through potential buffer areas.

D. Evaluating Soils for On-Site Waste Disposal

Soils are evaluated for their ability to support on-site waste disposal systems, and as part of the evaluation the depth to "seasonal high" water table is estimated. This is a crude and archaic approach because it does not predict how long the water table remains at a given depth, nor does it predict the frequency of saturation occurrence. The results of this study will demonstrate how on-site investigators can predict both how long and how often a soil is saturated at a given depth using soil color. This will improve site assessment procedures, and provide more information to determine the type of waste disposal treatment system that is best for an individual site.

Nature and Scope of Project

Wetlands are valuable because they enhance water quality, mitigate flooding, and provide habitat to plants and wildlife (Mitsch and Gosselink, 1993). Jurisdictional wetlands, or those protected by various federal regulations, are identified on the basis of three criteria: wetland hydrology, hydrophytic vegetation, and hydric soils (Environmental Laboratory, 1987). Hydrophytic vegetation is adapted to life in environments that are periodically devoid of molecular oxygen. Lists of such plants have been prepared for guidance in wetland identification.

Wetland hydrology occurs when soils are saturated to the surface or inundated with water for more than 5% of the growing season in most years. While hydrology is frequently referred to as the controlling parameter that determines whether a site will be a wetland or not, it is the most difficult of the three parameters to confirm. Measurements of water table levels are time-consuming and expensive to make, and for this reason water table measurements have not been made extensively over large geographic areas. Other visual indicators (drift lines, sediment on plants, watermarks, etc.) can be used as signs that a site has wetland hydrology. The accuracy of these indicators for determining wetland hydrology varies with the experience of the person making the interpretations. Even though such hydrologic indicators show that flooding has occurred, it is impossible to use these indicators to reveal frequency of flooding, or how long soils have been saturated.

Hydric soils are defined as soils that formed under conditions of saturation, flooding, or ponding that last long enough during the growing season for anaerobic conditions to develop in the upper part of the soil (NTCHS, 1994). These soils are expected to be saturated long enough to support the growth of hydrophytic vegetation. Hydric soils can be identified by their soil classification. However, field identification of hydric soils is expected to be done using hydric soil field indicators (USDA-NRCS, 1996). To a large extent, these indicators are color patterns that develop only when soils are saturated and iron reduction has occurred. The indicators include redoximorphic features which are the most common type of indicator found in soils that are saturated and reduced (Vepraskas, 1992).

The connection between wetland hydrology and hydric soil indicators is not simple, and has been shown to vary among soils (Vepraskas and Guertal, 1992). The indicators are produced when iron is reduced and dissolved by microbial processes, and moves either out of the soil or is concentrated into brightly colored masses or concretions (Mausbach and Richardson, 1994). The length of time a soil is reduced will vary with how long it is saturated, but also will depend on the amount of organic matter present, temperature, pH, as well as other factors. Thus, relating the amount of hydric soil indicators (e.g. percentage of redox depletions) to the length of time a soil is saturated will vary among soils that differ in organic matter content, pH, temperature and so on.

The Natural Resources Conservation Service has proposed in its soil classification system that the indicators found in wet soils do not reveal how long a soil has been saturated (Soil Survey Staff, 1994). While the indicators show that saturation has occurred, duration and frequency of saturation cannot be inferred from them. The only way to know how long and often a soil has been saturated during a year is to monitor water table levels. Once the water data have been determined, they can be compared to the type and amount of hydric soil indicators in the soil. This will in effect calibrate the features in a specific soil to exact frequencies and durations of saturation. This calibration can then be used to interpret how long similar soils have been saturated from the hydric soil indicators.

This approach has not been widely adopted because of cost limitations and because there is no general agreement as to how long a period of measurement is needed before useful data can be obtained. An alternative approach is to use hydrologic models that compute water table levels on the basis of rainfall data and soil properties such as hydraulic conductivity. Models such as DRAINMOD (Skaggs et al., 1993) have been proven accurate for simulating water tables. Care must be taken to use these models for conditions for which they were developed. Their accuracy can be improved by validating the input parameters for a given site. With such models it should be possible to compute historic water table variations over 30 year periods and to then use this record to calibrate the hydric soil indicators to specific periods of saturation. This approach should be less expensive than annual measurements of water table levels because measurements are needed only to validate the model and not to create a long-term record.

The objectives of this research are:

1. To estimate the cumulative time that the soils along a transect will be saturated each year for approximately 30 years using historic rainfall data and a hydrologic model;
2. To compute probabilities that each soil along a transect will be saturated at a given depth during a year;
3. To correlate the hydric soil indicators observed in each soil to the probability values determined in objective 2; and
4. To relate the hydric soil indicators to occurrence of iron reduction, sulfate reduction, and denitrification.